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EpiRadBio

Ultrasonography survey and thyroid cancer in Fukushima Prefecture

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SEVENTH FRAMEWORK PROGRAMME

HELMHOLTZ ASSOCIATION

Questions addressed

Under the condition of on-going ultrasonographic screening in Fukushima Prefecture, what are the expectations concerning thyroid cancer in the screened population?

1. Prevalence[a] during first screening
2. Subsequent incidence[b] independent of exposure from accident
3. Incidence due to exposure from accident
4. Detectability of radiation effect

[a] Number of cases per number of individuals screened

[b] Number of new cases per number of individuals screened during a certain time period

1. Prevalence

1.1 Basic assumption

If the same screening protocol would have been applied, then
the ratios of prevalence in screened cohort and country-specific incidence rate
in Fukushima Prefecture and in UkrAm cohort
should be are equal

$$P_{Fp} \,/\, \lambda_{Japan,Fp} = P_{UA1} \,/\, \lambda_{Ukraine,UA1}$$ for hypothetical same screening

1. Prevalence

1.1 Basic assumption (continued)

Ratios of prevalence in screened cohort and country-specific incidence rate in Fukushima Prefecture and in UkrAm cohort
are equal except a factor taking account of the study protocol, f_{sp}

$$P_{Fp} \,/\, \lambda_{Japan,Fp} = f_{sp}\, P_{UA1} \,/\, \lambda_{Ukraine,UA1}$$

1. Prevalence

1.2 Data on prevalence

UkrAm cohort, first screening: 13 127 participants, average age: 22 years

11.2 (95%CI: 3.2; 22.5) cases not associated with radiation

P_{UA} =0.09% (95%CI: 0.02%; 0.17%)

Tronko et al. J Natl Cancer Inst 2006

nodules > 5 mm / # nodules > 10 mm = 1568 / 475 = 3.3

Fukushima Medical University (2013)

http://www.fmu.ac.jp/radiationhealth/results/media/13-2_ThyroidUE.pdf

f_{sp} = triangular distribution [1; 3.2][a]

[a] based on data as of 31 July 2013

Jacob et al. Radiat Environ Biophys 2014

1. Prevalence

1.2 Data on prevalence (continued)

Size distributions in Hong-Kong study similar for nodules and tumors:

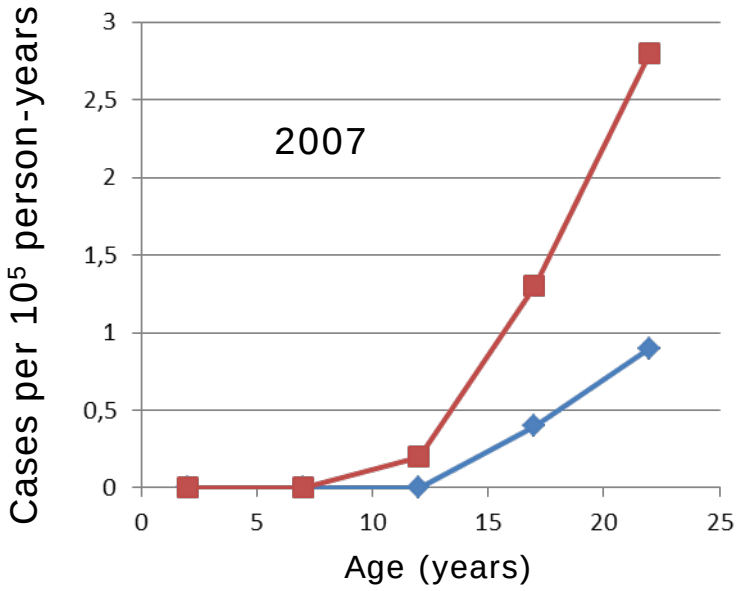
nodules > 5 mm / # nodules > 10 mm = 398 / 169 = 2.4

tumors > 5 mm / # tumors > 10 mm = 11 / 5 = 2.2

Yuen et al. Head Neck 2011

1. Prevalence

1.3 Data on country-specific incidence rates



National Cancer Center

http://ganjoko.jp/pro/statistics/en/ table download.html

$\lambda_{Japan,Fp}$ = 0.3 cases per 10^5 person-years (0.0003 %/year)

$\lambda_{Ukraine,UA1}$ = 1.8 cases per 10^5 person-years (0.0018%/year)

1. Prevalence

1.4 Results on prevalence

Municipalities/Prefectures	Targeted period of screening	Predicted prevalence (%) [a]
13 in Fukushima Prefecture	Apr 2011–Mar 2012	0.027 (0.007, 0.069)
12 in Fukushima Prefecture	Apr 2012–Mar 2013	0.034 (0.009, 0.088)
Aomori, Yamanashi and Nagasaki	Nov 2012–Jan 2013	0.032 (0.008, 0.084)

[a] arithmetic mean and 95% confidence interval

Jacob et al. Radiat Environ Biophys 2014

Observed prevalence in municipalities targeted April 2011 – Mar 2012:

13/41493 = 0.031 % as of 30 Sep 2013

Fukushima Medical University (2013)

http://www.fmu.ac.jp/radiationhealth/results/media/13-2_ThyroidUE.pdf

2. Incidence not related to radiation from accident

2.1 Screening factor for incidence

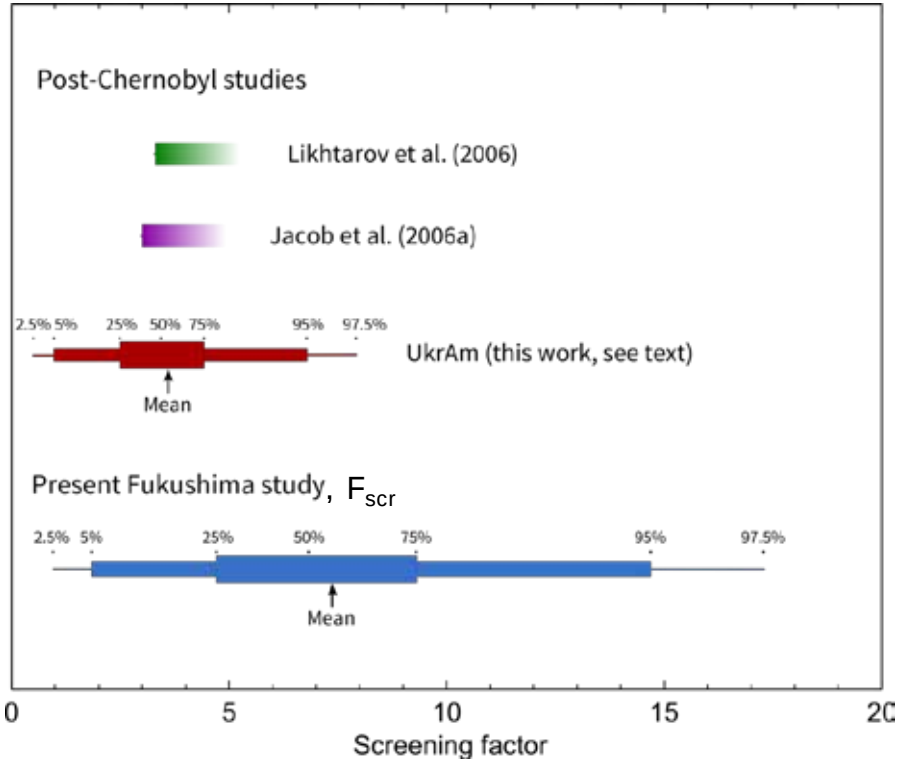
Screening factor in Fukushima Prefecture

= Screening factor in UkrAm cohort * f_{sp}

= $(EAR_{UA}/ERR_{UA})/\lambda_{Ukraine,UA2\text{-}4}$ * f_{sp}

= 7.4 (95% CI: 0.95; 17.3)

Brenner et al. Environ Health Persp 2011
Jacob et al. Radiat Environ Biophys 2014



2. Incidence not related to radiation from accident

2.2 Results

Presented in Section 3

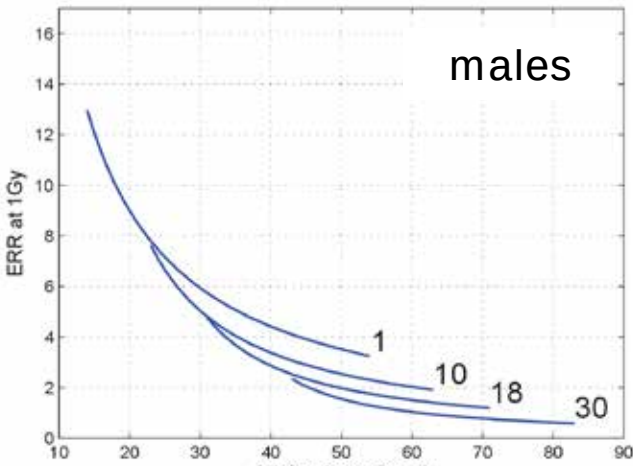
3. Incidence due to exposure from accident

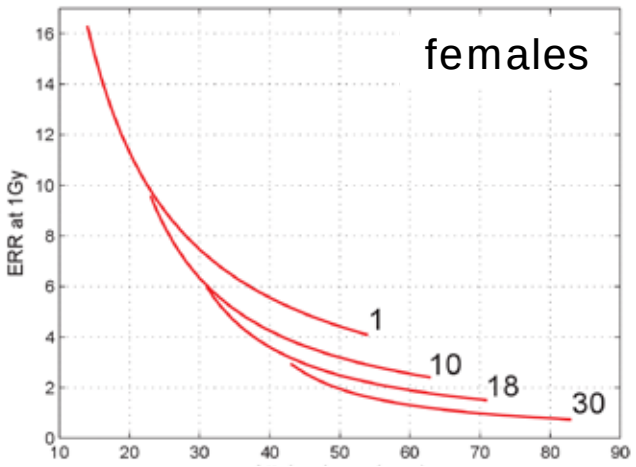
3.1 Risk model for LSS members not participating in AHS

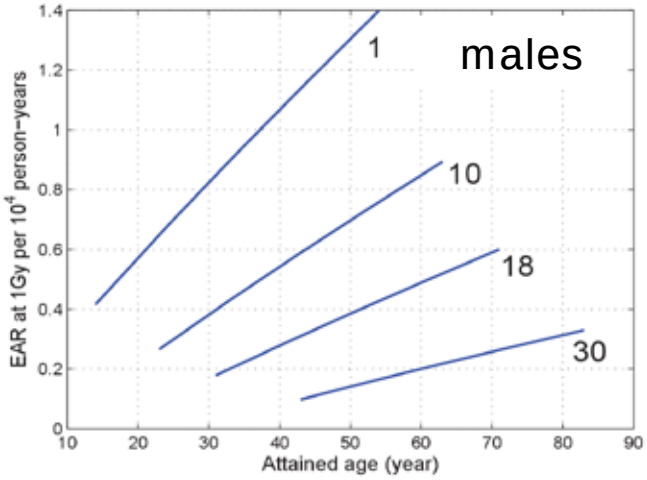
Relative risk decreases with increasing age at exposure and age attained

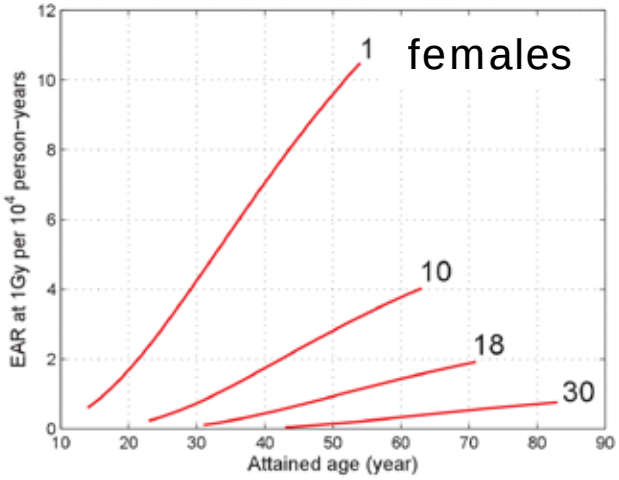
Excess rate decreases with increasing age at exposure and increases with increasing time since exposure

Jacob et al.
Radiat Environ Biophys 2014









3. Incidence due to exposure from accident

3.2 Excess absolute rate per unit dose

Transfer of relative risk from LSS to Fukushima Prefecture

$$EAR_{Fp}(s,e,a) = F_{scr}\, F_L(a\text{-}e)\, F_{DDREF}\, ERR_{LSS}(s,e,a)\, \lambda_{Japan}(s,a)$$

F_{DDREF}	Uncertainty due to transfer to low dose and low dose rate
$F_L(a\text{-}e)$	Minimal latency period of 3 years
F_{scr}	Screening factor

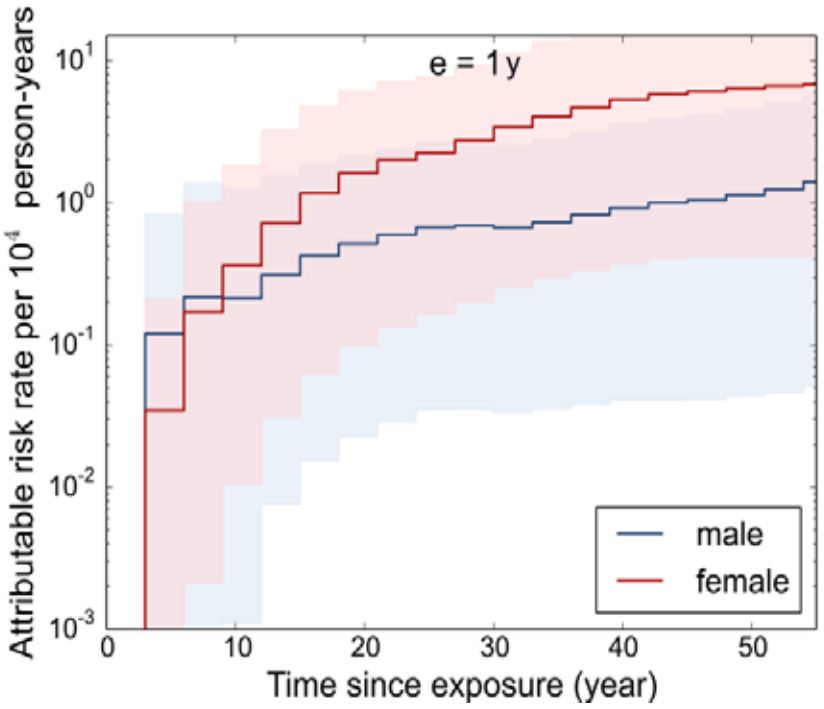
Heidenreich et al. Radiat Res 1999 (F_L)
Jacob et al. Occup Environ Med 2009 (F_{DDREF})
Jacob et al. Radiat Environ Biophys 2014 (F_{scr}, ERR_{LSS})
National Cancer Center, http://ganjoho.jp/pro/statistcs/en/table download.html (λ_{Japan})

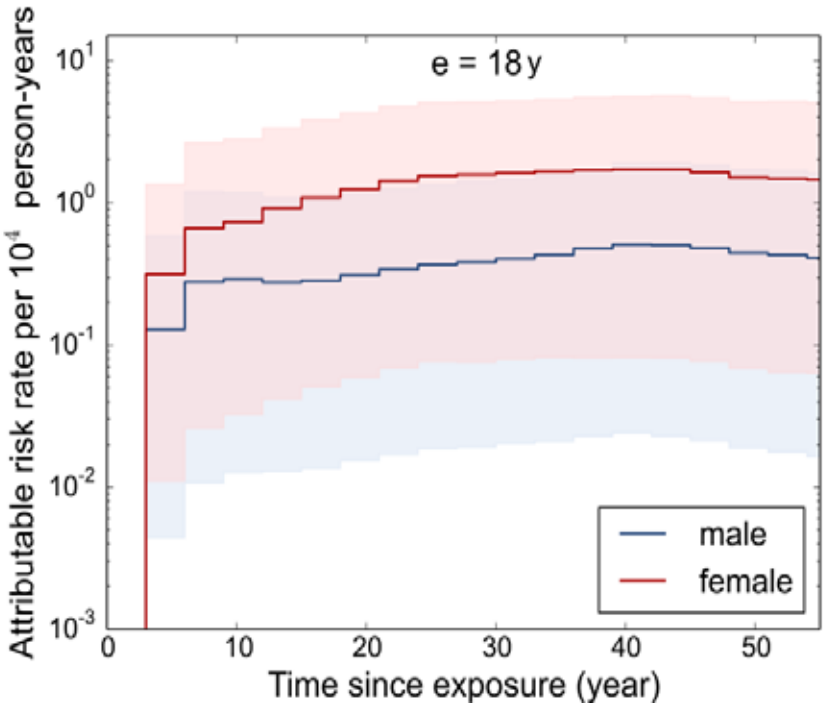
Predicts zero excess rate for young age attained

=> mixed transfer more plausible

3. Incidence due to exposure from accident

3.3 Excess absolute rate at 100 mGy





Jacob et al. Radiat Environ Biophys 2014

3. Incidence due to exposure from accident

3.4 Predicted incidence during two time periods

Baseline and attributable to ***assumed*** thyroid dose of 20 mGy

Thyroid cancer	Incidence (%)	
	10 years	50 years
Baseline	0.06 (0.006; 0.14)	2.2 (0.27; 5.3)
Excess	0.006 (0.0002; 0.025)	0.13 (0.005; 0.40)

Main sources of uncertainty: F_{scr}, ERR_{LSS}, F_{DDREF}

Jacob et al. Radiat Environ Biophys 2014

3. Incidence due to exposure from accident

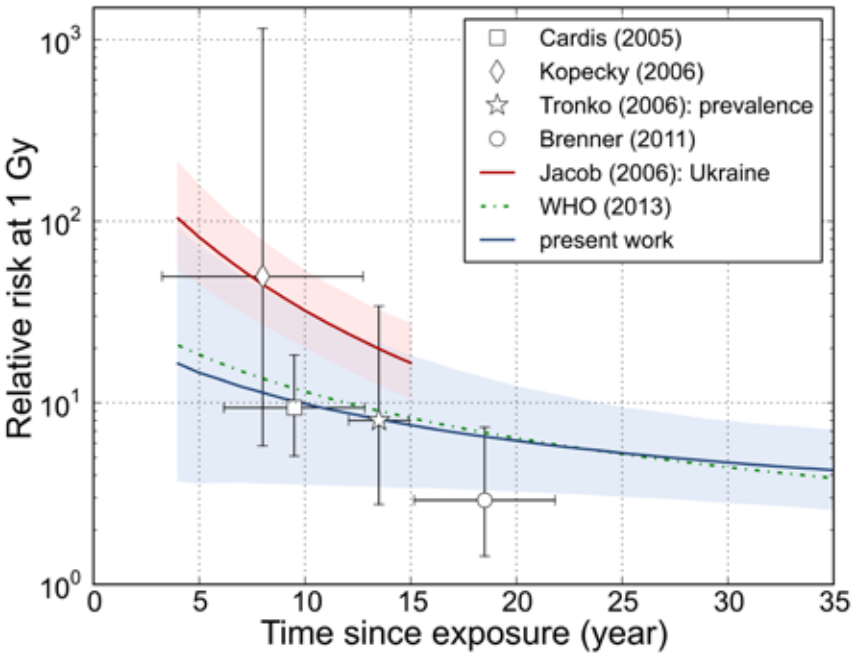
3.5 Will radiation effects become detectable?

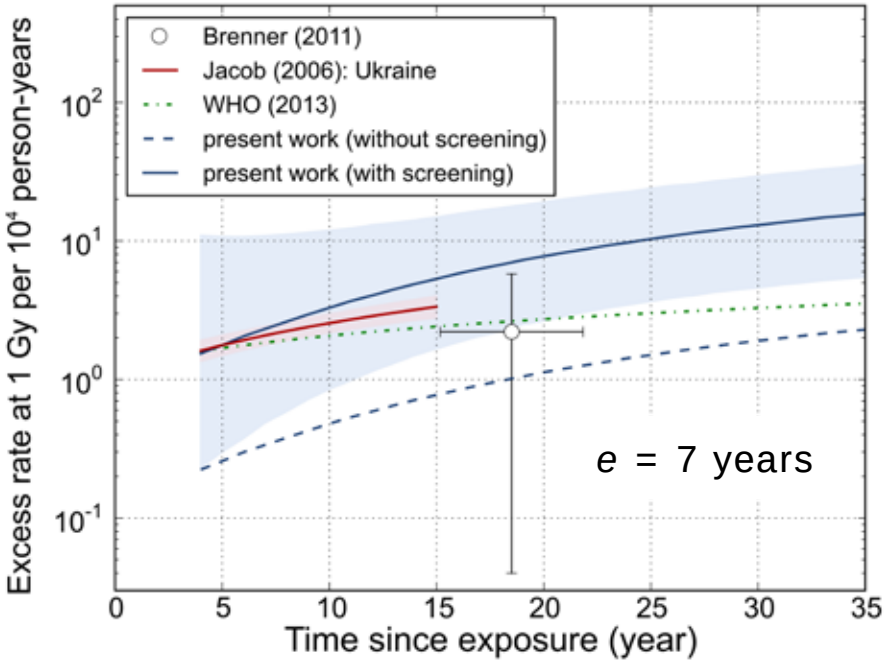
According to best estimates for female infants:
If a few thousand female infants would have a thyroid dose in the order of 50 mGy,
then the radiation effects will possibly be detectable after several decades

However, uncertainties are large:
Radiation effects may also become detactable for lower doses or smaller exposed groups

4. Comparison with other studies

4.1 Excess risk for thyroid cancer in post-Chernobyl studies





4. Comparison with other studies

4.2 Thyroid cancer risk predictions for 100 mGy by WHO (2013)

Females, 10y at exposure	WHO (2013)	Jacob et al. (2014)	Ratio
LAR	0.25%	1.6%	6.5
RR, lifetime	0.33	0.24	0.7
AR_{15}	0.03%	0.09%	2.9
RR, 15 years	1.1	0.53	0.5

Compared to WHO (2013), Jacob et al. (2014) predict

- higher thyroid cancer rates, because of ultrasonography survey
- slightly lower relative risks especially for first few decades after exposure of girls, because of differences in radiation risk function

Summary of predictions for continued ultrasonography (1)

Predictions based on prevalence and screening factor in UkrAm study, and thyroid cancer risk function in LSS members not participating in the AHS

Prevalence during first screening: 0.034% (95% CI: 0.009%; 0.085%)

Screening factor for incidence rate: 7 (95% CI: 1; 17)

Thyroid cancer incidence over 50 years: 2% (95% CI: 0.3%; 5%)

Excess 50y-incidence from thyroid dose 20 mGy: 0.1% (95% CI: 0.005%; 0.4%)

Summary of predictions for continued ultrasonography (2)

Excess 50y-incidence from thyroid dose 20 mGy: 0.1% (95% CI: 0.005%; 0.4%)

Less than 5% of 50y-excess accumulate during first 10 years

Large uncertainties related to F_{scr} , ERR_{LSS}, F_{DDREF} and thyroid dose

Good agreement with post-Chernobyl studies

Compared to WHO higher rates,

but lower relative risks (especially for first decades after exposure of girls)

Summary of predictions for continued ultrasonography

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Thank you for your attention !